A MONOGRAPH OF THE AUSTRALIAN SPONGES.

By Dr. R. von Lendenfeld.

II.—Continued.

MORPHOLOGY AND PHYSIOLOGY OF THE SPONGES.

I will endeavour to give a brief account of our present knowledge on the subject, without entering into detail, which will be described below in the classificatory portion of this work.

I.—The Anatomy of the Sponges.

1. *Shape and size.*

Although many Sponges have a constant shape, which is characteristic for the species, still the greater number do not possess a definite form. The same species will always be characteristic in outer appearance, but a certain shape which could be minutely described and set up for a standard is not met with in most Sponges. Just as a tree although growing irregularly, will have peculiar points about it, which give the character to the landscape so it is with the Sponges.

The irregular Sponges appear in every conceivable shape. Those which have a constant shape are generally cylindrical, always with a circular transverse section, which points to the fact that we have here animals before us, which originally irregular, are just commencing to attain a regular radially symmetrical shape, or *vice versa*. The latter appears more probable.

In detail the form of a species is very constant, so that Sponges from the same locality growing in the same depth, and under similar outer circumstances, will always at first sight prove their identity, may their shape differ ever so much.

The configuration of the surface, the height of the projecting conuli, and their distance from each other, and the size of the Oscula are alike. Also, the structure of the skeleton is much more constant than the shape.

The more we go into detail the more constant peculiarities are met with, so that the microscopic investigation will often prove two specimens to be identical, which are very different in shape.

The size is subjected even to greater variations than the form. Many Sponges certainly do not grow beyond a certain limit, but there are others which grow indefinitely—that is all those forms, which are found in the shape of incrustations. Spongecrusts may extend for miles. The margins of different crusts coalescing, and finally covering the whole of the area in which the Sponge in the struggle for life has the upper hand.

Such a Sponge is for instance our Aplysilla violacea (1) which covers many thousand square meters in Port Phillip. In such cases it is difficult to say what should be considered as an individual.

Whilst the Sponges with characteristic shape can be easily recognised either as single persons or as colonies of such, whereby all individuals are alike and more or less separate, these unlimited sponges can only be understood as Zoa Impersonalia (Oscar Scmidt.) Together with the characteristic and constant shape we find the individuality of the Sponge slowly disappearing, whereby not clearly personified individuals are derived from personified species of definite shape. This certainly tends to prove that these indefinite Sponges are not to be confounded with higher individualized Cœlenterata, but we must always bear in mind, that they pass an embryonic stage, which is of characteristic, constant and

---

(1) R. von Lendenfeld. *Ueber Cœlenteraten der Südsee II. Neue Aplysinidæ.* Zeitschrift für wissenschaftliche Zoologie. Band, XXXVIII.

definite shape, so that the loss of individuality which occurs later is not the original, but only a coenogenetic peculiarity. The largest Sponge of definite shape and attaining a height of one metre or more is Poterion.

2. *The color.*

In many Sponges the color is less variable than shape and size, even in the indefinitely shaped species it never varies near as much as often in higher animals. I consider the colour in life as a very constant and characteristic feature, so much so, that I would always be inclined to consider a Sponge as belonging to another species; when the color differs though otherwise similar in shape and structure. Unfortunately the colour is very delicate and always fades in spirits or changes even totally in a few minutes.

The outer surface is mostly monochromatic, although it happens sometimes that one part of a Sponge is lighter than another. Spots or figures of any kind never occur in the surface color. Sponges may have all colors except green. (Spongilla sometimes contains chlorophyll and then appears green.)

When the colour is not uniform then the lower side is always lighter than the upper, as in fishes. This appears to be less of a protective arrangement than a consequence of the photographic effect of the light, which causes the exposed surfaces of the Sponge to attain a darker hue than those which are always in shade. If the colour of the Sponge is not uniform then the lighter part is always the same tint as the darker, only a lighter shade. We have here apparently the same difference as between the colours of the soles and palms and the other part of the skin of dark human tribes. Deep sea Sponges are always colorless.

The Calcareous Sponges are white or light yellow, the Horn-sponges always richly coloured, yellow, orange, blue, red or violet; the Siliceous Sponges, with the exception of those from great depths (Hexactinellidæ and Lithistidæ) also appear coloured, but not so intensely as the Ceraospongiæ. The interior of the Sponge is mostly of a similar hue as the surface but always more dull.

The color may be diffuse, but is also often exclusively found in granules which may be imbedded in the gallert or in the cells of the Sponge.

Of the changes which the colours of Sponges undergo when dying, those are most remarkable, which are met with in the yellow Aplysinidæ and Aplysillidæ, they turn dark blue.

3. *Internal structure.*

The skin or outermost layer of the Sponge is often only loosely connected with the main part of the body, and can be removed from the concave fields between the conuli.

The body appears on a transverse section, more or less porous. The pores are the orifices of the channels which traverse the body of the Sponge in every direction. The lumen of these canals varies very much so that in some cases the Sponge appears very porous, only about 30% of the space being taken up by the Sponge substance itself, whilst all the rest is canals. In other cases again the canals become rare and narrow and are often quite invisible. This, for instance, often occurs, when a living Sponge is cut, because the whole of the body contracts so much that all the vacant space is filled up by the Sponge tissue and all the water ejected.

Also the hardness is subject to great variations. Some Sponges, without skeleton, appear very soft, nearly slimy; whilst others again, particularly the Lithistidæ, attain the hardness of a stone. But not only does the skeleton make a difference in this respect, the ground substance of the Sponge itself varies greatly in its density between the slimy appearance of a soft gallert and the resistent form of cartilage.

4. *The Canal-system.*

The canals are mostly crooked and irregular, only in a few Sponges they appear, as more or less, parallel and straight tubes. Their breadth varies very much, although it often happens that they will all appear of the same width in a section. From the microscopic pores of the surface the water either enters cavities which lie underneath the skin, the subdermal cavities (Carter) or flows through small canals which join and form larger tubes.

These tubes afterwards again give rise to smaller ones, which by continual ramification finally supply the greater part of the whole Sponge. In no part of the Sponge this system of canals, through which the water flows centripetally, is in direct connection with those canals through which the water passes on to the oscular tube. There is always a layer of ciliated chambers present in the Sponge, which layer separates the ectodermal canal system which brings the water to the ciliated chambers, from the canal system which carries the water away from the chambers to the oscular tube, these latter canals are coated with Entoderm. The layer of ciliated chambers is mostly folded in a very complicated manner. Originally it has always been of a simple sack-shape, from which shape the complicated structure of the adult Sponge is derived. (F. E. Schulze Plakinidæ.)

The Ectodermal water-supplying canals are to be compared with trees which grow from the sub-dermal cavities or corresponding parts. Also, the Entodermal drain-channels are tree-shaped.

The narrow canals arising from the ciliated chambers unite to form larger branches which again, like tributary streams, run together, uniting to a main drain which opens into the oscular tube or cloaca. Only in a few Sponges, particularly the Syconidæ, the canal system is simple and unbranched. The Asconidæ (Leucosolenia) possess no canal system.

All the mains open into a tube very much wider than any of the others, which stands vertical on the surface of the Sponge. This Oscular tube is mostly very wide, always when expanded visible to the naked eye. It can be compressed, and may under circumstances be quite oblitered if the Sponge contracts very much. (Lipostomie.) This Oscular tube opens on the surface of the Sponge, with a simple, circular aperture. In the case of the Sponge being cylindrical, or consisting of a lot of parallel cylinders, there is nearly always an Osculum or opening of the Cloaca at the terminal face of every cylinder. Complications of this simple form of Osculum may arise, by a net-work being formed which closes the wide Osculum (Euplectella). Sometimes a thin chimney-shaped membrane projects from the Osculum. (Caminus.)

Sometimes a frill of large spicules surrounds the opening (many Calcareous Sponges, Holtenia.) The tube itself may possess transverse membranes, which by being more or less tightened regulate the current of water (some Spongidæ).

5. *The Skeleton.*

By far the greater portion of known Sponges possess a skeleton, which in its shape and size is as variable as the shape of the Sponge itself, but which in its minute structure appears rather unvarying. The daughters may have a very different skeleton from the mother as far as shape and size, probably also as far as strength is concerned; but the minute structure will resemble that of the parent so closely, that we are justified in looking on the minute structure of the skeleton as a very important feature of the Sponges in as much as their mutual relationship is concerned.

Some Sponges—and as we may safely assume, those resembling the ancestral forms—have no skeleton. One or several of such ancestral soft forms attained a skeleton, consisting of carbonate of lime (Calcarea.) Others again produced fibres, which were originally composed of fibrillous tissue only (Gumminæ.) In the course of time horny fibres were produced in the centre of the fibrellous fibres, and these of course followed the direction of the large canals (Oscar Schmidt). Originally they had a tree-shape (Aphysillidæ, von Lendenfeld, Vosmaer.) The branches coalesced, and a reticulate structure was produced, in which main centrifugal stems could be distinguished from tangental connecting fibres (Spongidæ, Aplysinidæ.) Foreign bodies, sand and the like, adhering to the surface of the Sponge, in most cases entered the horny fibres and filled the core of them in a varying degree. Such foreign bodies are mostly only to be found in the radial fibres, but sometimes also in the tangental ones.

Within these horny fibres sometimes cells are to be found, which like the Osteoklasts of the vertebrate animals destroy the hard substance, here the Spongiolin or horn, and cause the skeleton to appear as a system of tubes filled with a soft core. (Aplysillidæ, von Lendenfeld.) It is perhaps possible that these cells are Algæ symbyotic in the Sponge.

Silicious spicules may be formed within the horny fibres, and these always belong to the Monactinellid type, a rod with one or two points. They are small in number and size at the beginning (Veluspa, Miklouho-Maclay), but get larger and more numerous until the horny fibres are nearly entirely replaced by dense bundles consisting of Monactinellid spicules only.

At the same time in all of the stages from a soft non-skeletous Sponge (Halisarca), to a Sponge with a strong skeleton of silica-cords (Suberites), silicious spicules may be produced *outside* the fibres in the ground substance of the Sponge. These *never* belong to the Monactinellid type. They are always originally characterized by possessing more than two ends—more than one axis. These "flesh spicules" attain very extraordinary shapes. If they appear in Sponges, which already possess a strong fibrous skeleton, they remain small and loose (Desmacidonidæ, O. Schmidt); if on the other hand they make their appearance in Sponges which are destitute of a fibrous skeleton they attain a larger size and coalesce to form a hard, continuous skeleton (Hexactinellidæ, Tetractinellidæ, Lithistidæ. Monactipyalea.) Originally these spicules were small and scattered. Such ancestral forms were probably allied to the Plakinidæ (F. E. Schulze); or to those Chondrosidæ, which possess silicious bodies in their outer layer.

The Sponges are therefore, as far as the skeleton is concerned, to be grouped along two divergent directions, both of which take their origin in the Sponges without a skeleton. The one row comprises the calcareous, the other the horny and silicous Sponges. (Grant, Vosmær.) The latter group appears as a straight row (stem) culminating in those fibrous Sponges, in which all the horny substance has been replaced by Monactinellid silicous spicules, and comprising the horny Sponges, Ceraospongiæ (O.

Schmidt), and Monoctinellidæ (Zittel.) From the whole extension of this line or stem, branches take their origin, which are parallel to one another and run in the same direction. Large at the bottom, these branches taper towards the top ; they include the Desmacidonidæ (small branch near the top.) Plakinidæ, Tetractinellidæ, Lithistidæ and the Hexactinellidæ, two large branches at the bottom, and some Sponges which are allied to the Ceraospongiæ, near the middle of the stem, but nevertheless possesses flesh spicules. (Das System der Monactinellæ, von Lendenfeld and elsewhere.)

We will return to this subject further on, under the heading "Classification."

II.—The minute structure of Sponges.

As every other Metazoan, the Sponge consists of a great many cells, different in form and function ; and the products of these cells. It appears quite logical to call the Sponge a colony of Protozoa, but it must be borne in mind that every other Metazoan is just as much a colony of Protozoa, as the Sponge. The latter view is generally accepted, only that we do not *call* higher animals colonies of Protozoa.

The mass of the Sponge consists, like the Umbrella of the large Medusæ of connective tissue (Bindegewebe)· which may be of a more gallerty or a more cartilage-like texture. It is to be compared to the tissue which forms the umbilical cord known as Wharton's gallert. This ground substance is in many cases without visible structure, in others again it attains the characters of fibrous tissue, and then the whole Sponge accordingly has a tenacity like leather (Chondrosia.)

In this ground substance we meet with cells and all the surfaces of it are covered with Epithelia, so that the ground substance comes in contact with the surrounding water nowhere. These Epithelia are of a simple structure, and consist of one layer of cells only. The muscular fibres are not in connection with Epithelial cells, but produced from cells imbedded originally in the gallert, so that the main cause of the formation of a Sub-epithelial layer in other Cœlenterata does not influence the Sponges. And as there also do not seem to be any nervous elements in the Epithelia of the Sponge, no reason exists why a Sub-epithelial layer should be formed. (The origin of the Sub-epithelial layer in other Cœlenterata; compare O. and R. Hertwig, Das Nervensystem und die Sinnesorgane der Medusen.)

The ground substance, together with the cells imbedded therein, is to be considered as Mesoderm, whilst the Epithelia are partly Ectodermal and partly Entodermal. We shall commence with the description of the Ectoderm.

1. *Ectoderm.*

The whole outer free surface of the Sponge is covered with a low Epithelium, consisting of flat covering cells, each of which may possess one swinging cilia. The tubes which connect the outer surface with the inner canal system direct, or with the subdermal cavities are covered by a continuation of the Ectodermal Epithelium of the outer surface. The subdermal cavities and the canals leading from them to the ciliated chambers are also covered with the same Epithelium. Here the Ectoderm ends and all other surfaces of the Sponge are covered with Entoderm. (F. E. Schulze. Plakinidæ.)

According to the interesting observations of Marshall, it does not appear improbable, that the Epithelium on the surface also of those canals through which the water flows towards the ciliated chambers is to be considered as Entoderm.

In Reniera filigrana the parts of these canals adjacent to the ciliated chambers certainly are covered with Entoderm. But Marshall shows also in an extremely ingenious manner, that in those cases where these canals are originally rarely formed by the Ectoderm, they may be considered as Entodermal structures, because they are formed by an invagination, which takes place very early, and may therefore be considered as a sort of Gastrular invagination.

Whether numerous invaginations as those which according to F. E. Schulze form these canals, ought to be compared to the invagination of the Gastrula, it is here not the place to discuss, but if we followed this custom throughout, we would have to call the sweat glands in our skin also Entodermal, because they are produced by an invagination of the Ectoderm.

I think that an invagination of *Ectoderm* can never produce an Entoderm, but that an Entoderm can only be produced from an *indifferent* Blastula which does *not* consist of Ectoderm. In the case of the Sponge Embryo the outer surface is covered by Ectoderm, and the invaginations take place after the Entoderm has been formed.

The statement of Marshall, that the canals taking their origin between the Entodermal ciliated chamber, and the Ectodermal surface layer, by these two layers moving away from each other, after they have grown together (Plakina), may be formed *as likely* from the ciliated chambers as from the Ectodermal surface, appears indisputable; and I gladly accept it, because the digestive functions which I ascribe to the Epithel of these canals and the subdermal cavity, perhaps also point to an Entodermal origin of those cells.

2. *Entoderm.*

Whilst the Ectodermal cells, although performing manifold duties, are apparently (only few Sponges have been investigated with sufficient care) of a uniform shape, the Entodermal Epithelia are different in the different parts of the Sponge. In the ciliated chambers they are elongate, cylindrical, and contain a Protoplasma which imbibes colors very freely; in the canals leading from the chambers to the oscular tube, and on the surface of the latter they resemble the Ectodermal cover cells, although they never appear quite so low as these (Aplysillidæ, von Lendenfeld). The ciliated chambers in the Calcispongiæ often have the shape of long tubes (Radial tubes Syconidæ). In all other Sponges they are pear-shaped, sometimes elongated and sometimes nearly spherical They vary very much in size. (Sack-Birn-Halb.-Kugel förmig, F. E. Schulze).

These ciliated chambers are the main characteristic of the Sponges and have no homologue in other Cœlenterata. The cells which cover the inner surface of the chambers, always possess a frill at their free end, and a cilia in the middle of the free surface. Standing close together, and pressing each other laterally, they attain the shape of hexagonal prisms. At the vaulted end of the chamber a few of these cells here and there are wanting; here the pores are situated, through which the water enters the chambers from the supplying Ectodermal canals. These apertures are always very small, and it appears that the Sponge has the power of closing some or all of them.

Towards the other end of the chamber the cells get gradually lower and pass into the Entodermal Epithel of the drainage canals. There always is only one outlet, and this is of a large size, generally about half as wide as the chamber itself. It cannot be closed by the Sponge.

The Entoderm covers the surfaces of all the drainage-canals, and the oscular tube and ends at the margin of the latter. The boundary between Ectoderm and Entoderm lies in the circumference of the Osculum.

3. *Mesoderm.*

The same difference between the structure of the Mesoderm of the Polypomedusæ on the one hand and the Ctenophoræ on the other, (Hertwig der Bau der Ctenophoren, Chun die Ctenophoren des Golfes von Neapel), also appertains between the Mesoderm of Polypomedusæ and the Mesoderm of Sponges.

In some respects the Sponge mesoderm shows affinities to the Mesoderm of the Ctenophoræ. Whilst the cells in the ground substance of the Polypomedusæ, that is the primary Mesoderm, (von Lendenfeld: Encopella campanularia) have only a nourishing function and are derived from the Entoderm; the Mesoderm cells of the Ctenophoræ and Sponges have other functions also, and are in the Ctenophoræ (Kawolevsky) and, perhaps, also in the Sponges derived from the Ectoderm.

If we compare the Histology of the Sponges, Polypomedusæ, Actiniaria, and Ctenophoræ, we shall find that the four groups differ from each other in the following manner :—

The principal organs in the Ectodermal Epithel, Polypomedusæ.

The principal organs in the Entodermal Epithel, Actiniaria.

The principal—or many—organs in the primary Mesoderm or ground substance, Sponges and Ctenophoræ.

As mentioned above, the ground substance, which is a product or secretion of the Meso-dermal cells, mostly has the appearance of structureless gallerts, or harder substance, which in every case contains a large proportion of water. The minute fibrelles found in it run in every direction and are often dense and wavy so as to resemblance for instance the connective tissue in the cervical tendon of a bullock.

Cells of the Mesoderm.

The numerous cells of the Mesoderm have very different shapes. They possess a spherical or oval nucleus around which the Protoplasm is amassed. These cells are destitute of a cell-wall. From the central mass of Protoplasme prolongations extend exceeding in length the diameter of the central part manifold. These processes are not numerous 2-6. The most indifferent forms have processes which may extend in every direction. With a higher development of these elements their processes get fewer in number, and extending along one plane only. In the case of only two such excrescences being developed, they always lie at opposite ends of the cell and in one line—here we have arrived at a form of Mesodermal cell, which is to be termed a musular cell. Near the surface of the Sponge in the membrane which divides the Sub-dermal cavities from the outer water these cells have their prolongations extended in a tangental plain, they are mostly two in number but sometimes also three are met with. Around the canals and the Oscular tube we often find these cells in dense masses, and their prolongations mostly running parallel to the adjacent surface. The extensive movements of the outer skin and the canals is doubtlessly the result of the contraction of the processes of these cells. The interesting fact of their being sometimes, particularly in the skin, such cells with three processes, show a mode of the formation of muscular tissue, very different from that known in the other Cœlenterata in detail, but still essentially the same. (von Lendenfeld neue Aplysinidæ, Kleinenberg Hydra.)

A tube consisting of a dense mass of such Mesodermal cells covers in some Sponges the fibres of the skeleton. These cannot be considered as muscular, but rather as a sort of tissue like the periost.

Another interesting and much more differentiated form of Mesodermal cells are large gland-cells, which invest the growing horn-fibres of Ceraospongiæ and secrete the horn substance. (F. E. Schulze, Spongidæ). Similar cells are met with along the outer surface of the sponge. These produce a slime which protects the Sponges from noxious influences from without. (Merejkovsky, Eponges de la mér blanche, von Lendenfeld neue Aplysinidæ.)

These cells have the shape of round balls of Protoplasm, investing the spherical nucleus from which threads of Protoplasm 3-10 in number take their origin, and remaining parallel with each other connect the body of the cell with the surface where the secretion is to be poured forth. These threads are as long or longer than the main body of the cell and stand vertical on the surface of secretion.

Cells in the core of the hollow-fibred Sponges, which act like the Osteaklasts, and produce the pith in the fibres of the Sponges, are also derived from the Mesoderm. (von Lendenfeld das Hornfaserwachsthum der Aplysinidæ.) (1)

It appears from this that the skeleton of the Ceraspongiæ is a Mesodermal structure.

The cells in the Protoplasm in which the calcareous and silicious spicules take their origin, also belong to the Mesodermal layer, and are of an indifferent shape.

We now have to review a series of Mesodermal elements, which are alike in shape at certain stages of their development, but which perform very different functions.

(1.) Possibly symbiotic Algæ, compare Brandt Chlorophyll bei Thieren.

Amœboid wandering cells, very much like amœbæ with lobate Pseudopodia are common in all parts of the Sponges, their function is merely to serve as vehicles of food and oxydized substances, as we shall see in the chapter on Physiology.

Some of these cells are developed into the generative elements. The form ova and Spermasacks around which an endothel-like Follicle is formed by other Mesodermal cells.

The sperma forming cells are of a peculiar kind (Polejaeff Spermatogenese von Sycandra raphanus) with a Protoplasm which refracts the light in a greater degree than any other cells. By continuous partition of this cell, finally a heap of small cells are produced, which produce a tail and turn into Spermatozoa. These always consist of a narrow, sharp, lance-point-shaped head and a long tail. The proximal part of the tail is immovable and thick, it tapers abruptly to the thin moving distal part.

The ova are not produced in the same manner as the Spermatozoa, it is probable that each amæboid cell only produces one ovum. (von. Lendenfeld. Neue Aplysinidæ.)

All these amœboid cells, the wandering cells always, and the sexual cells in their young stages creep about very actively in the ground substance of the Mesoderm.

Similar amœboid cells are known in the Medusæ, but of course the sexual products do not take their origin from these in the higher Cœlenterata.

III.—Embryology.

The development of the Sponges, and particularly the first stages, can easily be studied, because the embryos remain within the mother until they have attained a pretty high degree of development. In the shape of oval ciliated Gastrulæ they leave the mother and swim about in the sea water for a short time. They then fix themselves to anything suitable and grow out into the Sponge. This latter part of the Ontogenesis is the most difficult to investigate, it is only of late that F. E, Shulze, Keller, and Marshall have succeeded in attaining an insight into the changes which the ciliated and free swimming embryo undergoes before it produces the Sponge.

The cell division does not take place in the same manner throughout. In the Calcispongiæ the young Morula consist of a ring of cells with a hole right through the centre, connecting the oral pole of the larvæ with the aboral. In other Sponges such a stage does not exist, but only a solid morula which produces secundary in the interior, a space, or a Furchungshöhle. All Sponges seem, however, to pass a Blastula stage. The single layer of cells which constitutes the wall of the Blastula may be produced by the coalescing of the oral and aboral apertures (Calcispongiæ), or by the ordinary process of an imbibition of water by the solid morula.

In the central mass, which Marshall calls Cœnoblostem, first Nuclei seem to make their appearance. Marshall thinks that the whole Cœnoblostem resembles a Syncitium. Other observers are inclined to consider these Nuclei as belonging to cells, the limits of which escape observation.

In this state the embryo leaves the brooding place, swims about for some time in the canals of the mother and finally leaves them. The cells of the outer layer, which now can be called Ectoderm, produce one cilia each, and the movements of these cilia propel the young Sponge. In some groups (Ceraospongiæ, Reniera, and other Silicispongiæ) the embryo has a pigmented spot on one end of the oval body, which might perhaps be considered as an eye. The embryos of Reniera filigrana, a Sponge which grows on the lower-side of stones, &c., shuns the light and always seeks the darkest corner of the aquarium. In some cases a ring of particularly long cilia surround the pigmented spot. The bulk of the Cœnoblostem increases in size continually and soon bursts the formerly continuous Ectoderm and protrudes slightly from the apertures. The Ectoderm is always torn at the end of the rotation-axis of the oval Embryo. The pigmented cells are thereby pushed aside and form a ring which surrounds the naked Cœnoblastem. The Ectodermal cells retract their cilia and the embryo, after showing irregular movements for some time, finally affixes itself. The Cœnoblastem flows towards the aboral aperture, which is greatly dilitated and soon sticks to the surface, which the embryo has chosen as his abode for life.

Now a small cavity makes it appearance in the centre of the Cœnoblastem, which may have the shape of a ring (Plakina) or a lens. This original Gastral cavity is perfectly homologous to the Gastral cavity of all those Embryos of other Metazoa which produce their Entoderm by delamination and not by direct invagination. From this simple cavity soon sack-shaped excresences grow forth. The ciliated chambers produced at their termini form short excrescences which connect them with the surface. In this manner tubes are formed, the commencement of the introductory canal system. In a similar manner the Oscular tube is formed from the gastral cavity.

As to the further development of the Sponge from this indisputed stage, there are two opposite opinions, and both from such authorities, that it will be best to state both without commentary.

Schulze believes that by a complicated process of continual folding the sponge is finally produced in such a manner that the introductory canals are nothing else than parts of the original free surface of the Sponge, at the sides of which two portions of the outer surface which have come in close contact by the formation of a fold, have coalesced.

Marshall on the other hand thinks that all these canals are formed from the ciliated chambers by sending tubes centrifugally, which when they reach the surface open there and so form the introductory canal. The outer surface remaining from beginning to end unfolded and unchanged.

Further investigations will be necessary to show which Sponges are developed in the former and which in the latter way. I refer the reader to the statements made above under the heading Ectoderm.

IV. Physiology.

The investigations on this subject are still fewer in number than those on the former subject, and as yet hardly permit of generalisation.

1. *Skeleton.*

a. Calcispongiæ.

The skeleton of the Calcareous Sponges consists as the name indicates partly of Calcium.

The chemical composition which is met with in the Sponges, is the carbonic acid salt; Ca C O_3, with very little organic substance, which mainly forms the narrow and often invisible axial canals.

The calcareous spicules, which sometimes attain a considerable size, are produced as a *secretion* by cells and grow by apposition. Ca C O_3 and Ca S O_4 are always in abundant solution in sea water. These substances are taken up by the Sponge-cells in contact with the water (Canal Epithelæ), and transmitted to Meso-dermal cells, which produce the skeleton.

b. *Silicispongiæ.*

The skeleton of the silicious Sponges consists, of Si O_2 chiefly. There is always an axial canal, composed of organic substance, and it appears that there are also sometimes concentric layers of siliceous acid and organic substance intermittent. The young spicules contain more organic substance in proportion than the old ones, and appear therefore softer and can easily be dissolved in re-agents.

Also, these spicules seem to originate always in cells, sometimes (Hyalonema), they attain a length of 10 Cm. and a thickness of 2-4 mm. They grow, as the concentric layers in their substance indicates by apposition. The silica is procured from hydrate of siliceous acid, Si H_2 O_3, or from soluble siliceous salt, which are met with in small proportions in solution in the sea water. Si Ka O_3 for instance.

c. *Ceraospongiæ.*

The horny substance which forms the greater part of the substance in the skeleton of these Sponges, and many of the Monactinellæ is a substance similar to hornchitin or silk, F. E. Schulze calls it Spongiolin. Several chemical analysis have been made of it. The percentage of nitrogen is very great.

The horny fibres of the Sponges are the product of certain gland cells Spongoblasts, described above, which *secrete* horny substance. The fibres always consist of concentric layers and grow by apposition only and not by apposition and intussusception. (F. E. Schulze: Die Familie der Spongidæ. Von Lendenfeld: Das Hornfaserwachsthum der Aplysinidæ.)

d. The fibrils of Hircinia.

In the European Sponges belonging to the Genera Hircinia and Oligoceras, and also in some Sponges not belonging to these Genera, which I have found on our shores, we meet with a dense mass of fibrillæ, long threads with a nob at each end, which may be considered as a peculiar kind of skeleton. They never form the only skeleton of the Sponge, but are always associated with a well developed hornfibre skeleton, and sometimes also with siliceous spicules (Von Lendenfeld das System der Monactinellæ.) Their accessary appearance makes it not improbable that they are, or belong to a parasitic organism. The researches which were carried on to elucidate this point at the Zoological Laboratory in Graz, under F. E. Schulze, by myself, and others, did not lead to any positive result. The analysis shows that these fibrils also contain a great proportion of nitrogen.

2. *The ground substance.*

The ground substance appears as a secretory product of the numerous star-shaped cells imbedded therein and has a similar chemical constitution as glue.

3. *Foreign bodies.*

Sponges are often rich in foreign bodies, which may be of any nature, provided they have the proper size. Nevertheless certain Sponges generally select certain foreign bodies. The most common are sand and spicules of other Sponges, which, after the death and decay of these, have dropped to the bottom of the sea.

Ceraospongiæ nearly always contain, more or less sand and other particles in their main radial, sometimes also in their tangental fibres. Sometimes also such bodies are met with in the ground substance of body or skin. They fall on the surface of the Sponge, the Ectodermal epithel cells give way to them, they enter the body of the Sponge and are lead to their place of destination. Particularly interesting are pointed bits of quartz (sand) which are selected with great care. They are always of the same shape, and placed in the skin of a Ceraosponge, with the points centrifugally as weapons of defence. (Von Lendenfeld, Neue Aplysinidæ.)

4. *Digestion.*

This most important subject is unfortunately also one of the most difficult to investigate. Experiments with carmine-feeding nd other observations seem to show that the digestion is *intra-cellular.* The carmine particles are taken up freely by all Epithelia of the Sponge, but they are soon ejected from all the cells except those which cover the introductory canals.

These cells do not eject all the carmine at any rate, but pass some of it on to the wandering cells which carry it about, dissolve some of the substance (the angular particles loose their sharp edges), and finally seem to pass it on to the cells of the ciliated chambers.

Whether the Sub-dermal cavities and introductory canals really are the digestive cavity as I believe, or not, cannot yet be known. (von Lendenfeld, Neue Aplysinidæ), although my experiments have convinced me of the high probability of it.

The cells of the ciliated chambers are in my opinion to be excluded from all functions which have to do with the taking up of nourishment. (Polejaeff Challenger-Calcarea.)

Excretary functions and breathing.

I assume (von Lendenfeld, Neue Aplysinidæ), that the cells of the ciliated chambers are the excretary elements, that they act as kidneys, and I am also enclined to believe that through them the exchange of oxygen and carbonic acid is effected. Their shape, and also other observations point that way. The wandering cells transport the chemical substances which are either necessary for the organism or superfluous to the places where the former are wanted and the latter ejected.

V. The Systematic Position of the Sponges.

The Sponges are, as I have had occasion to mention above, like all Metazoa, colonies of single cells or roughly speaking, Protozoa. They are very low animals, and so the similarity of them with a congregation of Protozoa is greater than that of higher Metazoa.

There has existed since 1867, when Leukart placed the Sponges under the Cœlenterata, a dispute, whether the Sponges are Metazoons or Protozoons. The greatest authorities on the subject consider them as Cœlanterata (Leukart, Haeckel, Claus, F. E. Schulze, Marshall, Vosmaer, Ray Lankaster), whilst others, particularly the majority of English authors, who in otio cum dignitate, do not take much notice of what anyone else does (O. Schmidt, Vorwort zu den Spongien des Meerbusens von Mexico), and the Americans consider it ridiculous to call the Sponges Cœlenterata, but persistently call them colonies of Protozoa.

To me this dispute seems very useless, and in fact ridiculous. Of course the Sponges are colonies of Protozoa, but so are the Medusæ and corals; of course the sexual propagation is initiated by conjugation—but so it is in the Medusæ and corals. Of course the Sponges consist of a zoaglealike ground substance in which cells are imbedded and which is surrounded by Epithelia—but so do the Medusæ and corals.

There are of course great differences between Medusæ and Sponges—but are there not as great difference between a parasitic cirrhiped and a lobster? Among the essays on this subject which have been published recently, there is particularly one which I shall translate here, because it points out the matter so clearly and simply. (Marshall, Die Ontogenesis von Reniera filigrana. Zeit. schrift für wissenschaftliche Zoologie Band, XXXVII. Seite, 239-246.

It is known (but it does no harm to point to it from time to time) that Leukart (1) drew attention to the fact that the Porifera belonged to the Cœlenterata in the first instance. This was in his review of Lieberkühn's Essays on the Anatomy of the Calcispongi.

(1.) Jatresberichte, 1864-65, p. 196 and 197.

Here he follows the results gained by this author "in die letzten Konsequenzen hinein," and proves his theory for the first time in a decided manner.

He, in the first place, drew attention to the homology between the ciliated cavity of the simple Calcispongiæ (Grantiæ), and the gastral cavity of a Hydroid Polyp. He compared the mouths of these two with one another, and he dwelt on the accessory difference between them; that in the one case tentacles surround the mouth whilst the other has no arms. The pores of the Sponges he compares with the numerous cases of waterholes in the Cœlenterata. (1.)

"Allerdings," Leucart continues:—"Sind nun nicht alle Poriferen so einfach organisirt, wie die Kalkschwämme, vielmehr ist die Mehrzahl derselben mit eniem Höhlensystem versehen, welches mit der weiten Leibeshöhle der Grantien und Syconen nur geringe Æhnlichkeit hat, allein es ist zur Genüge beckannt, dass der coelenterische Apparat auch soust durch peripherische Ausstülpungen und Verästelungen die mannigfachsten Formen annimmt."

In these words nearly everything is contained that concerns the comparison between the morphological structure of the Sponges and the Coelenterata; only that these ideas can be further worked out and that a few words can be added about the Ontogenesis and Phylogeny of these two large groups.

Balfour (2) is inclined to consider the Sponges as a type of Metazoa developed separately for itself from the Protozoa. And this appears to him to be proved by the following facts:—(1.) By the peculiar structure of the free larvæ; (2.) By the early development of the Mesoblast in the Sponges, and particularly (3) by the remarkable structure of the digestive canals.

As far as the first reason is concerned, I am not inclined to consider it as sufficiently general; the remarkable pecularities of

---

(1.) Haeckel, who, extraordinary to say, did not know Leukart's deductions, compares six years later the Sponges and Acalephes in nearly the same manner. Kalkschwämme. Band I. Seite 462, M.A.O.

(2.) Balfour. A Manual of comparative Embryology, Vol. II., p. 309.

the larvæ of Sponges compared with those of other Cœlenterata are only met with apparently in the Calcispongiæ. The Ceraospongiæ have precisely the same larvæ as some higher Cœlenterata, Eucope for instance. Of course one might consider the larvæ of Eucope as consisting of two layers, and Balfour does that, but it is the question whether this procedure is not somewhat arbitrary. One might consider it also in the following light: Into the cavity of a Blastosphæra cells enter from the Ectoderm, which in time fill this cavity, and in this manner form a coenoblastem. Now delamination occurs in this coenoblastem and hereby it separates into a Mesoderm and an Entoderm which surrounds the delamination cavity and (compare also Kowalensky's original plate, fig. 8) consists of cells, which are differentiated in another manner as the cells forming the Mesoderm.

Also the second reason of Balfour's admits of a discussion.

The Sponges are a very old branch of the Cœlenterata and for a long time sessile in the adult stage, probably for a longer time than any other sessile Cœlenterata, as we can easily conclude from the early time of the affixing of the larvæ and the numerous adaptations which the Sponges have attained in connection with this way of living.

The sessility again caused the appearance of a skeleton here as in nearly all other cases where animals become sessile, which, whether it be of a calcareous, silicious, or horny nature (with the exception of a few very rudimentary Sponges) increased in size and density, from generation to generation, as most important to the Sponges. But the skeleton is not only a product of the Mesoderm of these organisms, it is even its principal product, and so the Mesoderm must have also increased in importance and size, the more the Sponges ceased to be solitary individuals and the more they commenced to form colonies, until it finally, as we see in many adult Sponge-colonies, overgrows the gastral cavities and depresses them nearly to a rudimentary organ.

The otherwise rare obliteration of mouth and gastral cavity which is sometimes met with, is caused by changes which have taken place in their function in the Sponges. These changes have caused the original water holes of the Cœlenterata to assume the function of taking up nourishment, whilst the digestive functions have been assumed by the Epithelia of the coelenteric canals. (1.) Another consequence of this change of function is the wonderful variety in shape which we meet with in the Sponges. Intercanal system, Pseudogastral cavities, &c., are transformed in all these changes, the outer surface of the Sponge always increases in size, and the number of pores through which nourishment is taken up is increased. The sum of all these peculiarities not only favoured the development of the Mesoderm but it was an efficient cause.

This deduction only would explain why the Mesoderm in the adult Sponges appears so much more developed than the other layers, but it would not be sufficient to disprove the second reason of Balfour's why the Sponges cannot be Cœlenterata. For this it is necessary to consider certain laws of heredity.

The law of heredity in the corresponding age (Haeckel's homochrone law) may be correct in general, but appears to be modified in some cases, particularly if it is in competition with settled heredity.

This later kind of heredity has the inclination to let peculiarities appear earlier and earlier from generation to generation, if these are particularly advantageous to the organism. *The sooner the progeny attains possession of peculiarities which have shown themselves as useful for the ancestors, the better for them.* (If not a pure recapitulation of the Phylogeny offers still better chances.) This is the main cause of the series of appearances called "shortened heredity." These peculiarities do by no means always appear in so striking a form, as for instance, among the crustations, they form moreover a finely shaded series, corresponding to the infinite variable conditions of existence in the living beings.

(1.) The whole process of this retrograde development can be compared to certain consequences of Parasitism.

It follows from this that the high development of the Mesoderm of the Sponges which has doubtlessly been developed and fixed in such a degree, during a very long series of generations, must finally have commenced to make its appearance in the larva, particularly if this was not only not disadvantageous but useful for the larva. This latter is doubtlessly the case with the silicious spicules which make their appearance so very early in the larva, and have saved many of them from being eaten. I don't believe that the free ancestors of the Sponges ever possessed a skeleton, this will, according to all analogy, have been formed as a consequence of the sessility.

The third reason, lastly, which Balfour brings forward to prove that the Sponges are not Cœlenterata, is therefore of particular interest, because it is one of those which induced Leukart to decide *for* the Cœlenterate-nature of the Sponges, only that the one author puts the differences between the development of the gastral cavity in Sponges and Cœlenterata forward, whilst the other attaches particular importance to the similarity of the two; but we know that when we have to do with modifications of homologous organs, as evidently in this case, the *affinity* must be considered as a proof of the old genetic connection, and is therefore the *essential* part, whilst the difference points to a special attainment, and is therefore *accidental.*

In both groups we see that a canal system has been differentiated which extends centrifugally from the gastral cavity, which often penetrates the Ectoderm (in Sponges, with the exception of the problematic Physemaria always), and which opens with constant or variable pores outward; where tentacles are met with, the canal can enter them and here (Actinia) or also in other places (Rhizostomæ), can open outward with pores; and as in the latter case astomy occurs, nourishing materials are taken up through these pores just as in the Sponges.

Ciliated cells are widely spread in the gastral cavity of Cœlenterata, if they also don't mass themselves locally to form ciliated chambers. But this is also by no means the case with all Sponges.

(1.) If Balfour (2) says that the ciliated cells which cover the ciliated chambers or radial tubes of the Sponges undoubtedly originate from the invaginated cells (*i.e.*, the ciliated cells of the Ectoderm), then I would like to state that they certainly did *not* originate from those, they are moreover in Sponges and Cœlenterata modified elements of the Ectoderm which *may* be produced originally from the Ectoderm in some cases, (invagination) but not necessarily must be produced by the Ectoderm (delamination.)

If we once more compare the canal system of Sponges and higher Cœlenterata, we shall see that it can open outward free in both, that it can be covered with entodermal ciliated cells for a greater or smaller extent, and that lastly it can take up nourishment through its terminal pores in both.

Another reason which is generally brought forward against the Cœlenterate nature of the Sponges is, that the Sponges never possess tentacles or Cnidoblasts.

Without placing too great a weight on the want of both in Beroë which is a rudimentary form in this respect I only wish to discuss: Have the ancestors of the Sponges ever possessed tentacles and Cnidoblasts? and if yes, how have they lost them? If no, why were these not attained in the course of time.

Cnidoblasts or their Homologa, respectively Analoga and tentacles are so widely spread among low marine animals, and are met with in so very different animals, that they cannot be used as a determinant for the relationship, as they are arrangements doubtlessly often attained sua sponte. But as they are met with in higher Cœlenterata (3) in different modifications, nearly without exception, they appear to be a very old peculiarity of these animals, which has proved itself as very useful in the struggle for existence, and which therefore could find such a wide distribution by heredity, in some cases perhaps by an adaptation sua sponte.

(1.) Kölliker. *Icones Histologicæ.* 1 Heft., p. 66.
(2.) F. Balfour, l.c., Vol. I., p. 144.
(3.) Which might be separated from the Sponges as Telifera or as Nematophora, Huxl., (because the name Cuidaria, nettle animals does not cover the meaning.)

The great phylogenetic age of these nettling organs is made likely by the fact that the Cnidoblasts are met with already, in the free swimming larvæ of some species, which is to be considered more as an exception than as the rule. This appearance of Cnidoblasts in the larvæ is probably produced by a very long-continued heredity, as this happened in an analogous manner with the mesoderm in the larvæ of the Spongiæ, as mentioned above. According to my idea, Cnidoblasts and their Homologa have been developed in connection with the tentacles firstly in the adult animal, as they have again disappeared in Beroë, together with the tentacles (1) they are parts of these (according to Chun, modified muscular cells) which have been changed in such a remarkable manner for purposes of catching prey. That they afterwards should have attained the functions of defensive weapons, and should then have been distributed all over the body does not appear so very wonderful. (2)

It is certainly difficult to ascertain whether the Sponges are—as not possessing tentacles and Cnidoblasts—rudimentary in this respect or not; whether their ancestors possessed them or not; is not of very great importance, this does not seem to have to do with the question whether the Sponges are Cœlenterata or not.

In the ontogenesis of the Sponge we never find a stage where anything homologous could be met with, just as little as we find any trace of anything of the kind in the adult Sponge. But both these facts do not prove that they really never had been present: also here the ontogenetic image of the Phylogeny might be dimmed, by a very long continued uselessness. It is, in case that the Sponge-ancestors rarely possessed these organs, not difficult to understand how they have been lost.

---

(1) If Protohydra, accepted as an adult animal, had been as lively and energetic as Beroë, also that animal could dispense with the protection of Cnidoblasts if it had no mouth-arms. But, if in reality the tentacles were the primary, and the Cnidoblasts the secundary thing, then Protohydra is certainly not an ancestral but a rudimentary form.

(2) Compare Cnidoblasts and their distribution among Cœlenterata, Pagenstecher Allgemeine Zoologie, Band II., pp. 24-27; particularly Band IV., pp. 259-263. Chun, Mikroskopische Waffen d. Cœlenteraten, Humboldt, Band I., Heft 2, 1882.

This was the natural consequence of the change of function of the water-pores and the Cœlenteric apparatus, — the ciliated chambers with their cilia-motion introducing nourishing material took the place of apprehensive tentacles, and with the latter the Cuidoblasts vanished, and the easier, the less the Sponges needed further protection in consequence of their extremely well developed skeleton, which also often contains very sharp spicules which are perfectly analogous to Cnidoblasts (for instance, the superficial floricome spicules of Euplectella (1). Sponges, which besides this often smell very badly, don't appear to have many enemies. In fact they seem not to be edible by other animals, which we may also conclude from the frightening colours (yellow, orange, vermillion, &c.,) of the sponges which grow in shallow water. Also, the animals which so often live in the cavities of the Sponges are, with the exception of a few minute parasitic algæ, not parasites, but only commensals, which find shelter in the detested Sponges.

It is, of course, possible that the Sponges branched off at a very early stage from the stem of the Cœlenterata, when they possessed neither tentacles nor Cnidoblasts.

Of much importance in this question the fact appears, that a radial structure is just as much exception in the Sponges as it is the rule in the higher Cœlenterata : both probably had bilateral symmetrical ancestors, out of which, perhaps in correlation with the tentacles, the higher Cœlenterata were developed as radial animals (? the Author).

This structure is also sometimes met with in young sponges (compare the Protactinia-stage of Reniera), and sometimes also in the adult.

The following may be the points of coincidence between Sponges and the higher Cœlenterata (2).

---

(1) F. E. Schulze. On the Structure and Arrangement of the soft parts in Euplectella aspergillum. Voyage of H.M.S. Challenger. Sponges Hexactin, pl. A, figs. 3, 4, 5. (Proc. Phil. Soc., Edinburgh, 1879, the Author.)

(2) This comparison, of course, is carried out with an ideal form which has been constructed out of the single peculiarities of different Cœlenterata, which are nothing else but different modifications of the same type.

Both groups are Metazoa with gastral cavities. Mesenterial pouches (which can, in the case of Sponges, be developed into ciliated chambers, ? the Author), centrifugal canals, which originate from the gastral cavity and open with pores outward, and (in some cases also in higher Cœlenterata) take in nourishment. These canals are,-(in Reniera) like the gastral cavity, clothed with Entoderm, which in both cases produces ciliated cells (probably not in all sponges, the Author). The genital elements of both are developed in the Mesoderm, but both can also multiply non-sexually by budding, (Tethya and Halisarca, the Author,) and form colonies by the same process, and both are very much inclined to become sessile. Both (the Sponges always and the other Cœlenterata mostly) possess a highly developed Mesoderm and extensive skeletons. In both groups there are forms which are developed in the same manner until they become sessile.

We can now, modifying Haeckel's (1) statement slightly, and comprising our investigations, say: *Porifera and Telifera (sit venia verba) are two divergent branches of the Cœlenterats, which have been developed from the common ancestral Protactinia.*

VI. Classification.

Several classificatory systems have been mentioned in the historic introduction, and I have had occasion to mention that here Zittel's classification shall be adopted. This of course concerns the orders of Sponges only, and also these I will have to modify slightly.

The opening up of a hitherto nearly unknown field of research, always necessitates a change in the previous ideas on classification, and the system which I have arrived at has the advantage of being based on a more extensive experience than any of the previous ones.

The material to be found in the northern hemisphere is in great part well enough described to admit of recognition, and to this, as

(1.) Haeckel. Die Kalkschwämme. Band I., p. 461.

one might say, codified knowledge, now is added the experience gained by the investigation of the rich and previously unknown Australian Sponge fauna.

In the systematic part of this Monograph the following classification shall be adopted. The reasons which have induced me to adopt this system shall be expounded anon, under the headings of the different groups.

SPONGIÆ.

CŒLENTERATA, WITH A GASTROVASCULAR SYSTEM WHICH OPENS ON THE SURFACE WITH MANY SMALL AND ONE OR A FEW LARGE APERTURES. NOURISHING MATERIAL FLOWS IN THROUGH THE SMALL PORES, THE LARGE PORES OR OSCULA ARE CLOACÆ. FRILLED CILIATED CELLS ARE GENERALLY AMASSED IN CERTAIN PORTIONS OF THE CANAL SYSTEM. ALL THE EPITHELIA CONSIST OF SINGLE LAYERS OF CELLS, THE MESODERM IS ALWAYS HIGHLY DEVELOPED.

I. ORDO CALCISPONGIÆ.

SPONGIÆ POSSESSING A SKELETON COMPOSED OF CARBONATE OF LIME WITH A LITTLE ORGANIC SUBSTANCE, GASTRULA FORMED BY INVAGINATION.

1. FAMILY ASCONIDÆ.

Calcispongiæ consisting of a thin walled porous sac.

2. FAMILY SYCONIDÆ.

Calcispongiæ with a thick wall, traversed by radial tubes (canals).

3. FAMILY LEUCONIDÆ.

Calcispongiæ with thick walls, which are traversed by ramified canals, which are partly in connection with the Oscular tube, and partly with the pores. Small ciliated chambers connect the two systems of canals.

II. ORDO MYXOSPONGIÆ.

SPONGIÆ WITHOUT ANY SKELETON, OR WITH ONLY FEW AND SCATTERED SILICIOUS BODIES.

1. FAMILY HALISARCIDÆ.

Myxospongiæ. The ground substance without a fibrillous structure.

2. FAMILY CHONDROSIDÆ.

Myxospongiæ the ground substance of which is tough, and has a fibrillous structure.

1. SUB-FAMILY CHONDROSINÆ.

Chondrosidæ without Flesh spicules.

2. SUB-FAMILY CHONDRISSINÆ.

Chondrosidæ with Flesh spicules.

III. ORDO CERAOSPONGIÆ.

SPONGIÆ WHICH POSSESS A SKELETON COMPOSED OF HORNY FIBRE, WHICH MAY CONTAIN FOREIGN BODIES BUT NEVER PROPER SPICULES. SILICEOUS BODIES RARELY DEVELOPED AS SMALL SCATTERED SPICULES IN THE GROUND SUBSTANCE.

1. FAMILY SPONGELIDÆ.

Ceraospongiæ with a skeleton composed of anastomosing horny fibres, with a narrow axial canal, The ground substance clear and transparent without granules. Ciliated chambers large sack-shaped.

1. SUB-FAMILY SPONGELINÆ.

Spongelidæ without Flesh-spicules.

2. SUB-FAMILY SPONGELISSÆ.

Spongelidæ with Flesh-spicules.

2. FAMILY SPONGIDÆ.

Ceraospongiæ with a skeleton composed of anastomosing horny fibres with very narrow axial canals. The ground substance filled with highly refractory granules and intransparent. Ciliated chambers small, semi-spherical.

1. SUB-FAMILY SPONGINÆ.

Spongidæ without Flesh-spicules.

2. SUB-FAMILY SPONGISSINÆ.

Spongidæ with Flesh-spicules.

III. FAMILY APLYSILLIDÆ.

Ceraospongiæ with a skeleton composed of tree-shaped and originally not anatomosing horny fibres, with a thick core surrounded by a thin layer of horny substance only. Ground substance transparent without granules. Ciliated chambers large and sack-shaped.

1. SUB-FAMILY APLYSILLINÆ.

Aplysillidæ without Flesh-spicules.

2. SUB-FAMILY APLYSILLISSÆ.

Aplysillidæ with Flesh-spicules.

IV. FAMILY APLYSINIDÆ.

Ceraospongiæ with a skeleton composed of anastomosing fibres which consist of a thick core and a thin horny wall. Ground substance filled with granules, intransparent. Ciliated chambers small and pear-shaped.

1. SUB-FAMILY APLYSININÆ.

Aplysinidæ without Flesh-spicules.

2- SUB-FAMILY APLYSISSINÆ.

Aplysinidæ with Flesh-spicules.

V. FAMILY HIRCINIDÆ.

Ceraospongiæ with a skeleton composed of anastomosing horny fibres with a narrow axial canal. The ground substance filled with granules. Besides there are dense masses of long and thin thread-shaped fibrilles with a knob at each end.

1. SUB-FAMILY HIRCININÆ.

Hircinidæ without Flesh-spicules.

2. SUB-FAMILY HIRCISSNIÆ,

Hercinidæ with Flesh-spicules.

IV. ORDO MONACTICERÆ.

SPONGIÆ WITH A SKELETON COMPOSED OF ANASTOMOSING HORNY FIBRES, WITHIN WHICH THERE ARE MONOAXIAL SPICULES. SOMETIMES WITH FLESH-SPICULES.

1. FAMILY CHALARCHIDÆ.

Monacticera with anastomosing horn fibres in the axes of which there are longitudinal minute biacerate spicules.

1. SUB-FAMILY CHALARCHINÆ.

Chalarchidæ wihout Flesh-spicules.

2. SUB-FAMILY CHALARCHISÆ.

Chalarchidæ with Flesh-spicules.

2. FAMILY CHALCŒNIDÆ.

Monacticera, with a dense mass of biacerate spicules in the axis of the anastomosing horny fibres.

1. SUB-FAMILY CHALCŒNINÆ.

Chalcœnidæ, without Flesh-spicules.

2. SUB-FAMILY CHALCISSINÆ.

Chalcœnidæ, with Flesh-spicules.

3. FAMILY CLATHRIDÆ.

Monacticeræ, with predominating truncated spicules in the axes of the anastomosing horny fibres.

1. SUB-FAMILY CLATHRINÆ.

Clathridæ, without Flesh-spicules, and without foreign bodies in any of the fibres.

2. SUB-FAMILY CLATHRISSINÆ.

Clathridæ, with Flesh-spicules and without any foreign bodies in any fibres.

3. SUB-FAMILY CLATHRILLINÆ.

Clathridæ, with foreign bodies in the connecting horny fibres, and without Flesh-spicules.

4. FAMILY ECHISPIDÆ.

Monactieeræ, with an anastomosing network of horny fibres, which contain biacerate or truncated spicules in their axis, and are clad with truncate spicules, the points of which are free. These spicules are always inserted at an angle of 45° and point centrifugally.

V. ORDO HYALOSPONGIÆ.

SPONGIÆ, WITH A SKELETON COMPOSED OF SILICIOUS SPICULES, WHICH HAVE ORIGINALLY BEEN FORMED AS FLESH-SPICULES, AND AFTERWARDS MAY COALESCE TO FORM HARD SKELETONS.

1. FAMILY PLAKINIDÆ.

Hyalospongiæ, with originally tetraradiate spicules, which do not coalesce but tend to become biacerate.

2. FAMILY HEXACTINELLIDÆ.

Hyalospongiæ, with hexaradiate spicules, which partly coalesce. Without a drainage canal system the large sack-shaped ciliated chambers open direct into a large oscular tube, which is closed at the osculum by a silicious net work.

3. FAMILY TETRACTINELLIDÆ.

Hyalospongiæ, with loose tetraradiate spicules, which are of variable shape, and partly tend to coalesce, with an outer hard layer containing dense masses of Flesh-spicules and often with subdermal crypts.

4. FAMILY LITHISTIDÆ.

Hyalospongiæ, with a skeleton, consisting of dense hard silica, which is developed by the coalescing of tetraradiate spicules.

VI. ORDO MONACTIHYALÆ.

SPONGIÆ, WITH A SKELETON, CONSISTING OF BIACERATE OR TRUNCATE SPICULES, WHICH MAY COALESCE SLIGHTLY, AND WHICH HAVE ORIGINALLY BEEN FORMED AS FLESH-SPICULES.

1. FAMILY RENIERIDÆ.

Monactihyalæ, with biacerate spicules, which tend in some cases to become truncate.

2. FAMILY SUBERITIDÆ.

Monactihyalæ, with predominant truncate spicules.